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THE IMPACTS OF AGRICULTURE ON WILDLIFE

By
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Final Report
Federal Aid in Wildlife Restoration
Project W-21-2 and W-22-1, Job 18.6R

(Printed May 1983)

FINAL REPORT (RESEARCH)

State: Alaska

Cooperator: None

Project No.: W-21-2
W-22-1

Project Title: Big Game Investigations

Job No.: 18.6R

Job Title: The Impacts of Agriculture on Wildlife

Period Covered: July 1, 1980 through June 30, 1982

SUMMARY

A bibliography of approximately 1,200 references was compiled on wildlife-agriculture interactions, and comments on this subject were solicited from biologists in North America. In addition, an inventory of current and future agricultural activity in Alaska was prepared. At the end of 1982, excluding acreage in large grazing leases, approximately 180,000 acres were in farmland. Conversion of additional acreage to farmland is planned, and 500,000 acres could be in agricultural production by 1990. An analysis of positive and negative impacts of agriculture on wildlife was completed. The major negative impacts as determined from the literature review and comments from biologists are loss or alteration of habitat, wildlife depredation on crops or livestock, effects of agricultural chemicals on wildlife, transmission of disease between livestock and wildlife, competition for forage on rangeland, and access problems for wildlife users. The major positive impacts include increased food for small game and waterfowl and the provision of resting areas for waterfowl.

Key words: agriculture, bibliography, depredation, disease, habitat loss, literature review, pesticides, predation, wildlife.

CONTENTS

BACKGROUND

Agricultural development became a goal of the State administration in 1976 amid concern about development of renewable resources. This followed soil surveys by the Soil Conservation Service which identified over 20 million acres as suitable for cultivation (Alaska Rural Development Council 1974, Alaska Agricultural Action Council 1981). Interest in agricultural development led to the Alaska Agricultural Action Council in 1979, mandated by the legislature with promoting and coordinating agricultural development within the State.

The 1st large-scale agricultural land disposal, Delta I, occurred near Delta Junction in 1978 with the disposal of 60,000 acres in 22 parcels averaging 2,500 acres each. Delta II East, 24,000 acres to the east of Delta I, and 15,000 acres in the Point MacKenzie area were disposed of in 1982. From 1978 through spring 1982, 60,000 acres were disposed of in small agricultural parcels throughout the State. At the end of 1982, excluding acreage in large grazing leases, approximately 180,000 acres were in farmland. Except for Point MacKenzie, which will emphasize dairy production, the primary current and projected use of this land is for production of grain crops. Developmental strategies call for the export of grain and the local use of grain to establish feedlots for a livestock industry.

Future land disposals are planned in other areas. Plans call for the disposal of 30,000 acres to be used for grain production on the west side of the Delta River. West of Nenana, in an area known as Totchaket, 175,000 acres are identified as suitable for agriculture (Furbush et al. 1980). The Agricultural Action Council has proposed a Phase I project in the Totchaket area of 75,000 acres in 1,000-3,000 acre farms. The State continues to sell agricultural rights to small parcels of land and to let grazing leases on State lands. In addition, private lands are also being converted to agricultural purposes.

Since 1978, the legislature has appropriated approximately $60 million for agricultural development with 82% of the funds used for low-interest loans to farmers and agricultural enterprises, and 18% of the funds used for direct appropriations to agricultural projects or village gardening programs (Alaska Agricultural Action Council 1982). With both political impetus and funding, agriculturalists are pushing for the rapid expansion of agriculture on State lands.

To date, there has been little study on the potential effects of agricultural development on wildlife in Alaska. This project was initiated to review pertinent literature and determine what the primary interactions between wildlife and agriculture have been elsewhere. With this knowledge, the effects of development can be anticipated and more informed decisions made regarding the means to minimize, mitigate, or capitalize on those effects.

OBJECTIVE

To analyze the potential effects of Alaskan agricultural development on wildlife and its users and to recommend means to minimize and mitigate negative impacts while amplifying beneficial effects of agricultural development.

METHODS

Methods are described in Appendix A.

RESULTS AND DISCUSSION

Review of Literature

A review of the literature on the effects of agriculture on wildlife is included in Appendix A.

Bibliography

A bibliography of approximately 1,200 references with index is included in Appendix A.

RECOMMENDATIONS

Recommendations are included in the literature review in Appendix A.

ACKNOWLEDGMENTS

I wish to thank J. Coady for providing direction and encouragement during the initial stages of this project. F. Dean assisted with bibliography design and J. Triplehorn, University of Alaska

reference librarian, spent many hours assisting with computer searching. W. Gasaway and W. Regelin provided encouragement as well as constructive criticism of the manuscript.

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APPENDIX A.

BIBLIOGRAPHY ON THE EFFECTS OF AGRICULTURE ON WILDLIFE AND WILDLIFE USERS

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APPENDIX A. BIBLIOGRAPHY ON THE EFFECTS OF AGRICULTURE ON WILDLIFE AND WILDLIFE USERS

CONTENTS

INTRODUCTION

Agriculture is expanding rapidly in Alaska. The State is subsidizing agricultural development through low-interest loan programs, construction of infrastructure facilities, and sale of agricultural rights on State-owned land. Since 1978 the Alaskan legislature has appropriated over $60 million to aid agriculture. The Alaska Agricultural Action Council has identified 20 million acres as suitable for cultivation; an additional 18 million acres may be suitable for grazing. In 1977, 70,000 acres were listed as farms, excluding large grazing leases, and 20,000 acres were in production. Since 1978, the State has sold agricultural rights to 84,000 acres near Delta Junction, 15,000 acres in the Point MacKenzie area, and 60,000 acres in small parcels throughout Alaska. Agriculturalists have targeted 500,000 acres to be in farms by 1991 and 1.5 million acres by 2000. Currently there are several large grazing leases on State lands and additional leases are pending.

The current trend toward large-scale projects is a significant departure from previous smaller scale agriculture. Interest in

grain and truck farming has been present since the early 1900's. The Tanana Valley was an agricultural area in the early 1900's, and in 1935 a Federal Government farming program established the Matanuska-Susitna Valley as a major agricultural area. Although there was significant interest in the dairy industry in the period 1940-1960, agricultural development as a whole has proceeded slowly in Alaska due to less expensive out-of-State products.

Large-scale agriculture has been incompatible with most wildlife species throughout North America. The extirpation of wolves and grizzly bears, which are intolerant of human activity and which cause livestock losses, has taken place in major agricultural areas. Bison also have been extirpated in agricultural areas, and other species have been reduced as well. With few exceptions, loss of habitat, pollution by agricultural chemicals, disease transmission from livestock, and conflicts because of crop depredation and predation all negatively impact wildlife.

Alaskans must know how agriculture has affected wildlife in other areas if we are to develop an agricultural program that minimizes or prevents losses of wildlife in Alaska. This review and bibliography draws together pertinent literature, describes the primary agriculture/wildlife interactions, and suggests how adverse interactions can be reduced or avoided.

METHODS

Bibliography Search Strategy

Computerized searches were used to find pertinent references on disease transmission between wildlife and livestock, loss or alteration of wildlife habitat because of agriculture, pesticide effects on wildlife, competition between wildlife and livestock, and depredation by wildlife on livestock or crops. Searches were limited to certain periods and topics because of the voluminous material on the subject (Table 1).

Additional materials reviewed were:

1. Wildlife Review (Vol. 138-181).

2. University of Alaska and University of Washington card catalogues using terms agriculture, pesticide, herbicide, and wildlife.

3. Lough, J. S. 1980. Bison and wisent (G. Bison) 1970-80. Wildlife Library, Univ. of Alaska. 16pp.

4. Vallentine, J. F. 1978. U.S.-Canadian range management 1935-77: a selected bibliography on ranges, pastures, wildlife, livestock, and ranching. Oryx Press,

Phoenix, Ariz. This bibliography was searched under diseases, range wildlife, big game, and livestock.

5. Winkley, B. 1974. 2,4-D and 2,4,5-T bibliography. Unpubl. rep., Wildl. Lib., Univ. Alaska.

6. Literature cited section of all publications acquired.

Most references are from scientific journals published since 1970 in North America and Europe, but some pertinent references from other times and areas were included. Search effort was directed at mammals and birds; if relevant, references on fish and invertebrates were included when found. From the many references on sheep-coyote problems, only the most pertinent were included. Most references on pesticides no longer extensively used in the United States were omitted.

Survey

In September 1981, a letter was mailed to 96 wildlife biologists and cooperative extension wildlife specialists throughout the United States, Canada, and Scandinavia requesting information on the most significant wildlife agricultural relationships in their area.

REVIEW OF LITERATURE

Crop Production and Wildlife

Effects of Crop Production on Wildlife Habitat:

Loss of wildlife habitat to large-scale agriculture and urbanization is a widespread and intensifying problem in the United States that impacts all wildlife species (McConnell and Harmon 1976). As older agricultural areas are converted to urban and industrial uses, land containing native vegetation is converted to crops. Between 1967-75, 30 million hectares were taken out of cropland for other uses, and 20 million hectares of pasture, forest, rangeland, or wetlands were put into crop production (National Research Council 1982). Construction of agricultural support facilities uses additional acreage and creates disturbances (Oxley et al. 1974, Mytton and Keith 1981). Even wildlife habitat left within agricultural areas is decreasing as small-scale farming is converted to large-scale farming.

The widely held notion that agriculture benefits wildlife by providing cover at the edges of fields and through diversity of habitat does not apply to most modern agriculture for many reasons. Large fields reduce habitat diversity and create barriers to wildlife (R. Holmes, pers. commun., Minn. Dep. Nat. Resour.). Woodlots not connected by fence rows become islands

providing little actual habitat (Wegner and Merriam 1979). Large and efficient machinery leaves little crop residues and increases mortality of field nesting birds (Labisky 1957, Zorb 1957, Milonski 1958). Monoculture and pesticide use reduce food and cover for many species. Fall plowing, roadside mowing, and removal of fence rows further reduce food and cover (Cornwallis 1969; H. Krauch, pers. commun., Purdue Univ.). Irrigation projects may lower water tables, drain wetlands, and destroy riparian areas (National Research Council 1982; A. Florio, pers. commun., Del. Dep. Nat. Resour.). As agriculture expands and intensifies, wildlife are concentrated on remaining habitat, which may result in increased disease or winter loss.

The reduction of habitat has detrimental effects on many species of wildlife. For example, loss of cover reduces numbers of big game (J. Osborn, pers. commun, N.C. Wildl. Res. Comm.; L. Oldenburg, pers. commun., Idaho Dep. Fish and Game). Increases in cropland result in changes in the composition of passerine birds with declines of many native species (Warbach 1958, Lockart 1978). Similarly, upland game species decline when cropland increases and agriculture intensifies (Buss and Dziedzic 1955; Swanson and Yocom 1958; Kirsch et al. 1973; Vance 1976; Zeigler 1978; D. Shroufe, pers. commun., Indiana Dep. Nat. Resour.; A. Florio, pers. commun.).

The only major benefit of modern large-scale agriculture has been the creation of resting and feeding sites for waterfowl. Swathed grain or cleared fields with crop residues are often used by waterfowl (Sugden 1976; R. Lund, pers. commun., N.J. Dep. Environ. Conserv.). However, breeding waterfowl use intensively farmed areas less than idle farmland or nonagricultural land (Dwyer 1970, Duebbert and Kantrud 1974).

Current large-scale agricultural development in Alaska differs from the previous small-scale farming, which had little adverse effect on wildlife habitat. Klebesadel and Restad (1981) credited agriculture for the increased moose (Alces alces) populations in the Matanuska Valley. Small farms of 40-60 acres settled in the 1930's and 1940's, plus fires and other forest disturbances, did increase habitat diversity and production of moose browse. However, large monoculture farms currently promoted in Alaska will not have the same effect. Tracts in the Delta I project are large (2,000-3,000 acres) and leave few fence rows or windbreaks for wildlife habitat. Barley fields and forb-grass meadows in this area supported fewer small mammals than other habitat types which were uncultivated (MacDonald 1980). Clearing of 60,000 acres removed habitat for many species; 3,000-4,000 acres of good moose winter range was lost (R. Larson, pers. commun., Alaska Dep. Fish and Game). Moose in this area use cultivated land less than other habitat types (D. Preston, unpubl. data, Alaska Dep. Fish and Game). On the positive side, fields have provided resting and feeding areas for migrating Canada geese (Branta canadensis) and sandhill cranes (Grus canadensis) (MacDonald 1980). The Delta I project has also

increased winter range for bison (Bison bison), but their use of these agricultural lands has created serious conflicts that jeopardize the long-term existence of the herd. Conversion of additional acreage in Alaska to intensively farmed cropland will be at the expense of wildlife habitat.

The State of Alaska has the power to affect the way agriculture develops to minimize losses of wildlife habitat. Currently the State is determining the size and type of new projects, selling only the agricultural rights and requiring farm conservation plans. These plans have not addressed retention of wildlife habitat but could be required to do so in the future. The State should encourage small farms that provide diversity of habitat. Green belts of State land should be retained between small parcels and within large parcels, creating corridors for wildlife movements as well as edge habitat. Woodlots and undeveloped areas should be along green belts to maximize habitat availability. Cultivation methods requiring little or no plowing should be encouraged to reduce soil erosion and leave crop residues for wildlife. Fencing designed to minimize entanglement of moose should be required. To mitigate habitat loss, alternative areas should be improved for wildlife habitat.

Effects of Agricultural Chemicals on Wildlife:

Modern agriculture uses large amounts of chemicals, some of which negatively affect wildlife. From 1950 to 1976, annual pesticide production increased 8,000-fold; from 60 formulations with 20 active ingredients in 1945, pesticides increased to 800 formulations with over 200 active ingredients in 1975 (Broadbent 1980). Farmers used approximately 400,000 metric tons of pesticides in 1977, and they applied approximately 44.5 million metric tons of fertilizers in 1976 (National Research Council 1982).

These chemicals affect wildlife species in a variety of ways. Important variables to consider when evaluating chemicals are concentration of pesticide or fertilizer, persistence in the environment, accumulation in plant or animal tissue, and species of wildlife impacted.

One primary class of agricultural chemicals is insecticides which include botanical, organochlorine, organophosphorus, and carbamate compounds. Use of botanical insecticides is decreasing in the United States and is not of particular concern to wildlife (Cremelyn 1978). Organochlorine insecticides such as DDT, dieldrin, aldrin, and heptachlor are generally very persistent, may accumulate in body fat, and concentrate along food chains. Use of these pesticides is declining in the United States, but residues remain (Caswell 1979). Organochlorides are still used extensively in developing countries. Use of organophosphorus and carbamate insecticides such as malathion, parathion, and carbaryl

is increasing. These compounds inhibit enzymes, primarily acetylcholinesterase. They degrade more rapidly than organochlorine insecticides, and are more readily metabolized but are no less toxic; many are among the most poisonous compounds known (Eaton 1973).

Other agricultural chemicals used extensively are herbicides, fungicides, and fertilizers. Herbicides such as 2,4-D, paraquat, and diquat act by regulating plant growth or desiccating plants. Fungicides compose a wide range of chemicals including both organic and inorganic compounds. Some, such as captan, have a very low toxicity, whereas others, notably some mercury compounds, have much higher toxicity. Mercury compounds are no longer used in the United States for seed disinfectants or to control fungal diseases on crops and grasses although residues may remain. In addition to active ingredients, pesticides often contain a carrier or base chemical that can also affect wildlife, e.g., diesel oil (Kopischke 1972).

Agricultural chemicals affect wildlife in many ways, e.g., acute and chronic toxicity, lowered reproduction, increased disease, and habitat alteration. Susceptibility to pesticides differs widely among different classes and species of animals and among different age classes of the same species (Rudd and Genelly 1956 in Hall 1980, DeWitt et al. 1960, Kenaga 1979a, Schafer 1972). For example, adult birds are generally more resistant than young birds to certain insecticides (DeWitt et al. 1960, Hudson et al. 1972). Animals at higher trophic levels are commonly exposed to greater dosages of chemicals because of residues in prey species (Davis 1974, Horstman 1976, Mendelssohn and Paz 1977, Hill and Mendenhall 1980). Synergism of pesticides or pesticides and other environmental contaminants can increase their effect on wildlife (Eaton 1973, Horstman 1976).

There are numerous examples of acute toxicity of agricultural chemicals to wildlife. Organochlorine, organophosphorus, and carbamate insecticides as well as herbicides and fertilizers have caused wildlife mortality (Lundholm 1970, Flickinger and King 1972, Hamilton and Stanley 1975, Mendelssohn and Paz 1977, Price 1977, Flickinger 1979, Felton et al. 1981, Stone and Knoch 1982, Zarnke and Taylor 1982). Stress may cause release of fat soluble organochlorine pesticides increasing brain residue levels and causing mortality (Labisky and Lutz 1967, Scott et al. 1975). Mercury used as a fungicide caused mortality in birds in Sweden and contamination of wildlife in North America (Tejning 1967, Borg et al. 1969, Fimreite et al. 1970, Krapu et al. 1973, Braun et al. 1977).

In addition to acute toxicity, some pesticides cause lowered reproduction or increased disease (Heath et al. 1972, Kenaga 1979a). Effects of organochlorines on reproduction in birds of prey are well known (Davis 1974, Stromborg 1979), and embryo development of fish and birds may be affected by 2,4-D, a herbicide (Lutz-Ostertag and Lutz 1970, 1973; Biro 1979). Certain

pesticides may increase the susceptibility of wildlife to disease or parasites (Friend and Trainer 1974a,b; Butler 1969 in Pimental 1971).

Pesticides also alter and often degrade wildlife habitat by reducing food and cover, resulting in declines in numbers and changes in distribution of wildlife (Keith et al. 1959, Johnson 1964, Hull 1971, Dwernychuk and Boag 1973, Moulding 1976, Bart 1979). Additionally, sublethal doses of 2,4-D, a herbicide, may affect plant metabolism resulting in quantities of nitrates that are toxic to livestock or wildlife (Stahler and Whitehead 1950, Willard 1950 in Pimental 1971, Keith et al. 1959, Caswell 1979). Conversely, wildlife occasionally benefit from herbicides that alter plant composition to favor browse species (Krefting and Hansen 1969).

Use of agricultural chemicals in Alaska will increase as agriculture expands and new pests are introduced, and problems common in other areas will develop in Alaska if the effects of agricultural chemicals on wildlife are not considered. The use of agricultural chemicals has already caused concern in Alaska after 14 bison were poisoned by ingesting urea fertilizer (Zarnke and Taylor 1982). Currently, in the Delta I project, insect pests are minimal and no insecticides are recommended (J. McBeath, pers. commun., Univ. Alaska). However, new insects will likely be introduced and insect pests may increase in areas of extensive monoculture. Herbicide use in Delta I and Delta II East will be minimal for the next few years because newly cleared lands generally do not have serious weed problems and spring cultivation reduces weeds (J. Conn, pers. commun., Univ. Alaska). However, it is likely new weeds will also be introduced in seed or from used farm machinery. Therefore, wildlife habitat in agricultural areas will likely be adversely affected by herbicides and insecticides in the future. Also, occasional poisoning of wildlife by agricultural chemicals is likely.

The risk to wildlife from agricultural chemicals can be minimized. The Department of Fish and Game and the Department of Environmental Conservation must ensure that waterways and wildlife areas are not contaminated with agricultural chemicals or silt. Monitoring of pesticide residues should be done in agricultural areas. New agricultural parcel owners should be informed about the toxicity of urea and other agricultural chemicals to wildlife and the importance of proper use of all chemicals.

Crop Depredation by Wildlife:

Crop depredation by wildlife is widespread in North America and often results in the elimination of wildlife to prevent further losses. Waterfowl, passerine birds, ungulates, bears, and small mammals all depredate crops. When agriculture expands into wildlife habitat, depredation is common. Agriculture also attracts some wildlife (e.g., waterfowl) that then cause crop losses.

Waterfowl damage to grain crops, principally wheat and barley, first became severe in North America in the 1940's following adoption of swathing grain as a harvest method (Colls 1951, Bossenmaier and Marshall 1958, MacLennan 1973). Mallards (Anas platyrhynchos), pintails (Anas acuta), sandhill cranes, and geese cause most damage. More grain is often trampled or fouled than is eaten, and damage is most common on large fields near wetlands (Hammond 1950 in MacLennan 1973, Bossenmaier and Marshall 1958, MacLennan 1973, Sugden 1976). Damage to swathed grain increases in years of late harvests or fall precipitation (MacLennan 1973).

Waterfowl damage approximately 1% of the crops in Canada; loss to Saskatchewan farmers was approximately $36 million annually in recent years (Burton 1978 in Stier and Bishop 1981). Depredation is generally less extensive in the continental United States.

Methods to reduce waterfowl depredations include growing crops not subject to depredation, growing early maturing crops, combining without swaths, leaving high stubble, not cultivating fields until neighboring areas are harvested, or increasing hunting pressure (Sugden 1976). Also, marginal farmlands suffering chronic crop damage may be converted to nonagricultural uses. Scaring techniques such as scarecrows, acetylene exploders, shooting, noisemakers, lights, and herding by foot, horseback, or aircraft are used extensively with varying effectiveness. If alternative feeding areas (e.g., feeding stations or lure crops) are not available, scaring may simply move birds to other fields and increase total damages because most damage occurs when birds first arrive in fields. Feeding stations may be the best solution in areas with severe damage, but they are expensive (MacLennan 1973). Compensation programs alleviate economic hardships for farmers but may create conflicting incentives; an alternative is to allow and encourage farmers to charge for waterfowl hunting privileges (MacLennan 1973, Stier and Bishop 1981).

Passerine birds depredate row crops, grains, and fruits (Stone and Mott 1973; Stone et al. 1973; Ismail et al. 1974; Dolbeer 1980; Stone and Danner 1980; Johnson and Timm 1981; T. Sutterfield, pers. commun., Hawaii Dep. Land and Nat. Resour.). Birds are most frequently controlled by poisons and scaring devices although diversification of agriculture may reduce depredation in some cases (De Grazio et al. 1972, Besser 1978, Stone and Danner 1980).

Bear damage to agricultural crops, such as corn, can be extensive where bears are abundant (Davenport 1953, Landers et al. 1979). Depredation on beehives by black bears (Ursus americanus) and grizzly bears (Ursus arctos) causes large losses (e.g., $133,000 in 1976 in the Peace River area of Alberta) (Gunson and Cole 1977b, Lord and Ambrose 1981b). To prevent repeated depredations, bears are frequently killed, e.g., during 1972-79, approximately 1,200-1,300 bears were killed in the Peace River

area (Gunson 1980). Depredation in combination with predation on livestock has been a primary factor in the decline and/or extirpation of bears in much of North America. Relocating problem bears was not satisfactory because bears commonly return or depredate elsewhere (Gunson and Pipella 1977). Electric fencing and elevated bear-proof platforms are the most effective means of protecting beehives (Lord and Ambrose 1981b).

Ungulates cause serious depredation to corn, soybeans, fruit, vegetables, small grains, ornamentals, and haystacks in North America (Hunt 1979; Mullen and Rongstad 1979; Wingard et al. 1981; N. Hancock, pers. commun., Utah Div. Wildl. Resour.; G. Moore, pers. commun., S.C. Wildl. and Mar. Resour. Dep.; P. Karns, pers. commun., Minn. Dep. Nat. Resour.). Problems are most severe at forest farmland edge, where rangeland or native vegetation has been converted to agricultural uses, or in years of weather-delayed harvest or heavy snowfall (Wilkins 1957, Hunt 1979).

Repellents, fencing, scaring techniques, and hunting pressure are used to control depredations by ungulates. Low effectiveness and limitations on use make repellents impractical for most situations (Wingard et al. 1981). Fencing is an effective but expensive method of control, e.g., 5-strand high-tensile electric fencing has been effective for excluding deer (Wingard et al. 1981). Scaring techniques move ungulates out of agricultural areas; however, effects are often temporary. In areas of heavy depredation, special hunts may be used to remove problem animals. For example, over 80 deer were shot in fall 1978 on 1 100-acre farm in Pennsylvania (Wingard et al. 1981).

Beavers (Castor canadensis) and muskrats (Ondatra zibethica) can cause damage primarily by interfering with irrigation systems or eating corn (J. Durell, pers. commun., Ky. Dep. Fish and Wildl. Resour.; A. Florio, pers. commun.). Raccoons (Procyon lotor), squirrels, and snowshoe hares (Lepus americanus) damage orchards, row crops, and gardens (C. McCord, pers. commun., Mass. Div. Fish and Wildl.; H. Nowell, pers. commun., N.H. Fish and Game Dep.).

In Alaska, farmers often assume that government agencies should investigate wildlife damage and pay compensation. Although a majority of states do investigate wildlife damage complaints, only 26 states are required to do so by law. Animal control is practiced by 45 states; usually state agency personnel harass problem animals, or establish special hunting seasons. However, only 10 states were required to make game damage payments in 1979 and the damage claim program in Wisconsin has since been terminated (F. Haberland, pers. commun., Wis. Dep. Nat. Resour.). The amount of liability, types of damage for which compensation is paid, and wildlife species covered varies by state (Table 2).

In the future, an increase in wildlife depredation to crops in Alaska is likely as Alaskan agriculture encroaches on wildlife habitat and wildlife become habituated to crops as an alternate

food source. Currently in Alaska, waterfowl depredation on grain crops is not serious because waterfowl do not normally concentrate away from nesting areas in late summer (Klein 1977). However, large-scale grain production is new to Alaska, and waterfowl distribution may change in response to agricultural development as has been observed in other areas (Colls 1951, Calif. Dep. Fish and Game 1980, Serdiuk 1981, D. Pursley, pers. commun., Md. Dep. Nat. Resour.). In addition, late harvests and large fields near wetlands, which increase the potential for waterfowl depredation, do occur in the Delta Junction area. Future waterfowl depredation problems in Alaska can be minimized by developing agricultural projects away from large wetlands.

Interest in beekeeping is increasing in Alaska. Platforms or electric fencing would prevent bear depredations on hives but are expensive.

Crop depredation by bison and moose is already a serious problem in some areas of Alaska. For example, bison have damaged barley on farms near Delta Junction, Alaska. Harassment and hunting pressure are used to reduce bison depredation, and an alternative range is being developed. Expenditures for these programs were $50,000 in 1981 and $15,000 in 1982. The appropriation for 1983 is $184,000. Moose have been a nuisance for many gardeners in rural areas of Alaska and may cause damage to cereal crops in the future. Farmers should be encouraged to use fencing and other nonlethal methods to protect crops.

Currently, there is no damage compensation program in Alaska and one is not recommended. Other states have found them difficult to administer, and they remove funds from other aspects of wildlife management. Lawsuits filed by Alaskan farmers to force the State to pay compensation have been unsuccessful. Alaska Department of Fish and Game personnel do assist landowners in reducing depredation problems. This should continue along with development of a policy on responding to animal damage complaints. In addition, an education program in ways to reduce crop depredation would be beneficial.

Livestock Grazing and Wildlife

Effects of Livestock Grazing on Wildlife Habitat:

Livestock grazing affects wildlife habitat by eliminating forage plants, changing height and density of vegetation, reducing plant vigor, altering plant communities, and changing successional processes. In areas where competition may not be evident under light or moderate grazing regimes, overgrazing can eliminate preferred forage and result in consumption of all palatable species by livestock. Vegetation can also be trampled or unavailable to wildlife because of fences or disturbances (Mackie 1978). Vegetational changes can affect water run-off, soil temperatures,

and soil erosion (Longhurst 1957, Lusby 1970). Important variables affecting livestock impacts on habitat are available vegetation, species and numbers of livestock and wildlife, seasons of use and grazing systems used (Dorn 1970, Mackie 1970, Skovlin and Harris 1970, Jensen et al. 1972, Schwartz et al. 1977).

All types of wildlife are affected by livestock grazing. Small mammals that require dense cover, such as voles and shrews, consistently decline in grazed areas regardless of habitat type (Page et al. 1978), whereas other small mammals that need more open habitat, such as jackrabbits (Lepus californicus), may be more abundant in grazed areas (Phillips 1936). A few bird species that also prefer open habitats may increase, but commonly, grazing reduces diversity of passerine species (Larsson 1969, Karuziak et al. 1977 in Kirsch et al. 1978, Page et al. 1978, Kantrud and Kologiski 1982).

Livestock grazing is generally detrimental to waterfowl and upland game birds (Yde 1977, Mattise 1978, Klebenow 1982, Kantrud and Kologiski 1982). Livestock trample vegetation around ponds, reduce nesting cover, destroy nests, or create disturbances (Bue et al. 1952, Salyer 1962, Burgess et al. 1965, Kirsch 1969, Gunnell and Smith 1972). Deferred and rest-rotation grazing systems may be better for waterfowl than continuous grazing, but they are not beneficial for upland game birds (Gjersing 1975, Mundinger 1976, Kessler and Bosch 1982). On areas managed primarily for waterfowl and upland game birds, grazing and haying should be restricted (Kirsch 1969).

Direct competition for food, cover, or space occurs between livestock and wildlife such as ungulates and small mammals (Howard et al. 1959, Hansen and Gold 1977, Gallizioli 1979, O'Meilia 1980). Elk (Cervus canadensis) and bighorn sheep (Ovis canadensis) are particularly sensitive to competition with livestock for forage, but studies have shown dietary overlaps between most big game and livestock (Merrill et al. 1957, Drawe and Box 1968, Houston 1968 in Dorn 1970, Skovlin and Harris 1970, Dusek 1975, Hansen and Reid 1975, Hubbard and Hansen 1976, Hansen et al. 1977, Olsen and Hansen 1977, Schwartz et al. 1977). As Mackie (1978:465) notes

> "Where even broad differences in food habits have been observed, as between cattle and deer, forage impacts may occur as a result of livestock use of certain plants available or utilized in only small amounts but yet important from the standpoint of the dietary needs of the wild ungulate."

Also, reduced cover from grazing can increase predation on wildlife or increase mortality of wildlife because of severe weather (Mackie 1978).

Riparian habitats are particularly sensitive to grazing pressures due to the tendency of livestock to congregate around water and

shade. Livestock use of riparian areas is nearly always in competition with wild ungulates (L. Oldenburg, pers. commun.). Grazing causes erosion of banks, with widening of stream channels, shallower water depths, increases in water temperatures, and higher storm flows (Gunderson 1968, Kennedy 1977, Severson and Boldt 1978, Makowecki 1980). These changes in stream characteristics reduce fish populations. For example, brown trout (Salmo trutta) were more numerous, heavier, and had a higher percentage of terrestrial insects in their diet in ungrazed as compared to grazed areas (Gunderson 1968, Marcuson 1970 in Kennedy 1977). Fences, alternate water sources, and salt are used to protect riparian areas (Severson and Boldt 1978).

Presence of livestock can influence the behavior of wild ungulates causing reduced use of habitat by wild ungulates, even when there is little direct competition for forage (Jeffery 1963 in Mackie 1978, McMahan 1966, Skovlin et al. 1968, Firebaugh 1969, Mackie 1970, Hood and Inglis 1974, Dusek 1975, Gallizioli 1976). Other management practices such as round-ups or the presence of herders can affect habitat use by ungulates (Hood and Inglis 1974). Fencing restricts availability of habitat to some ungulates and entanglement in fences can cause mortality to wildlife (Spillett et al. 1967 in Mackie 1978; Papez 1976 in Mackie 1978; D. Preston, pers. observ.). Gallizioli (1979:83) summarizes livestock interactions as follows:

> "It has long been a tenet of wildlife management that, on properly managed ranges, livestock presents no problem for wildlife. A corollary of this belief is that livestock grazing is actually beneficial to wildlife....There is, of course, a kernel of truth in these ideas. Unfortunately what is generally ignored is that qualifier 'on properly managed ranges'. Also ignored is the fact that the species of wildlife occasionally favored by grazing are seldom as desirable as those that are displaced. In reality,...the grazing of domestic livestock on western rangelands has probably had a greater adverse impact on wildlife populations than any other single factor."

In Alaska, there are currently over a million acres in grazing leases for cattle and sheep, which number approximately 12,000 head. In addition, 13 million acres on the Seward Peninsula are under permit for the grazing of approximately 19,000 reindeer (L. Adams, pers. commun., BLM). Another 18 million acres are considered suitable for grazing.

It is imperative that the expansion of livestock grazing be done with great caution to avoid the problems which have been so deleterious to wildlife habitat in other areas. Extensive livestock grazing will be at the expense of big game because all suitable land is now used by big game. Grazing should not be allowed in areas of critical winter range or in calving and rutting areas. Riparian areas must not be grazed to protect this

highly important habitat for fish, mammals, and birds. Bighorn sheep are particularly vulnerable to competition from livestock; we can expect the same of Dall sheep (Ovis dalli); therefore, grazing should be prohibited in or near Dall sheep range.

Disease Transmission Between Wildlife and Livestock:

Transmission of disease between livestock and wildlife can result in reduced wildlife populations because of introduction of diseases to wildlife and man's deliberate reduction of wildlife when it may expose livestock to disease. These problems are of particular concern as agriculture expands into new areas (Roth 1972, Wells et al. 1981). For example, concurrent with the introduction of domestic sheep on ranges in western North America, bighorn sheep suffered serious mortality from scabies mites that were probably contracted from domestic sheep (Buechner 1960, Sandoval 1980a,b). Bluetongue, contracted by bighorn sheep from domestic sheep, may also have played a major role in the disappearance of bighorn sheep from portions of Texas (Robinson et al. 1967). Disease and competition from livestock have kept bighorn sheep populations at a fraction of their original numbers. Besides introduction of new diseases, infection of wildlife with established diseases may increase following association with livestock (G. Moore, pers. commun.). In addition to direct mortality, disease can also cause increased susceptibility to predation, reduced reproduction, and higher mortality during severe winters.

Reduction or extirpation of wildlife to prevent infection or reinfection of livestock has also occurred in the United States. In some cases wildlife have contracted the disease from livestock and have then been slaughtered to eradicate the disease. For example, in 1924, over 22,000 black-tail deer (Odocoileus hemionus columbianus) were killed in California to prevent the reinfection of livestock with foot and mouth disease (Shillinger 1937) and in 1945, 20,000 white-tailed deer (Odocoileus virginianus) were killed in Florida to control the cattle fever tick (Boophilus microplus) (Kistner and Hayes 1970).

Diseases of concern to wildlife professionals and livestock owners include the following:

1. Brucella abortus is a highly contagious bacterial disease that causes abortion and joint disease in ruminants such as elk, moose, and bison. Other species of brucella cause disease in caribou (Rangifer tarandus) and carnivores (Fenstermacher and Olsen 1942, Jellison et al. 1953, Corner and Connell 1958, Meagher 1973a, Choquette et al. 1978, Hudson 1978, Thorne et al. 1978a,b).

2. Leptospira sp. is another bacterial disease that may cause inapparent to fatal disease depending on the serotype

and host. Although common to many wildlife, not all serotypes have been found in Alaska, and some populations have not been exposed. Once exposed, wildlife may serve as a reservoir of the disease (Roth et al. 1961, Diesch et al. 1970, Shotts and Hayes 1970, Cirone et al. 1978).

3. Bluetongue is a viral disease that can be carried by livestock (Bowne 1973). Massive die-offs of antelope (Antilocapra americana) and deer have resulted from bluetongue and epizootic hemorrhagic disease, a similar virus (Prestwood et al. 1974; T. Thorne, pers. commun., Wyo. Game and Fish Dep.). Also, bluetongue can cause mortality in bighorn sheep (Robinson et al. 1967, Jessup 1981). There is no evidence of bluetongue in Alaskan wildlife.

4. Bovine viral diarrhea, infectious bovine rhinotracheitis, and parainfluenza III are viruses that cause respiratory gastrointestinal or genital infections (Dieterich 1981). These viruses are often associated with other disease agents. Parainfluenza III was implicated in deaths of bighorn sheep attributed primarily to pneumonia (Howe et al. 1966, Parks et al. 1972).

5. Pseudorabies is a viral disease that can be carried by domestic swine and is found throughout the United States. Natural and experimental infections of wild mammals have been fatal (Trainer and Karstad 1963, Kirkpatrick et al. 1980). There have been no reported cases of pseudorabies in Alaska (R. Zarnke, pers. commun.)

Other diseases that could cause serious problems include anaplasmosis, tuberculosis, toxoplasmosis, ovine progressive pneumonia, contagious ecthyma, avian cholera, Newcastle disease, and internal and external parasites.

The most serious wildlife-livestock disease transmission problem in Alaska has been Brucella suis type 4, which is now enzootic in a number of wildlife species including caribou (Neiland 1975). Its origin may have been from reindeer introduced from Siberia in 1891 (Meyer 1964 in Witter 1981). Brucellosis reduces the productivity of caribou and reindeer herds and increases the impact of predation on populations. A vaccine has been developed for reindeer but will be impractical for use in caribou, so that reservoir of the disease will remain, and the effects on caribou will continue (Dieterich et al. 1979). Susceptibility of livestock to Brucella suis type 4 and the effectiveness of the new vaccine on livestock are unknown (R. Dieterich, pers. commun.). If livestock are susceptible, it would be unwise to introduce them to ranges occupied by infected caribou herds unless vaccination is feasible.

Besides problems with brucellosis, there have been few examples of transmission of disease between livestock and wildlife in Alaska primarily because livestock numbers have been low and

contact has been minimal. A serological survey of wildlife populations to more accurately determine exposure to disease and to monitor changes as the livestock industry expands is in progress (R. Zarnke, pers. commun.). Results of previous serologic surveys in Alaska show little or no exposure of Alaskan wildlife populations to major livestock pathogens (Table 3).

To minimize infection of wildlife with diseases, several precautions must be taken. Livestock imported into Alaska must be disease free. This can only happen when implementation of disease regulations is actively supported. Presently this is the responsibility of the State veterinarian. Surveillance of wildlife populations for exposure to livestock pathogens must continue. Because Dall sheep may be particularly vulnerable to disease (as are other wild sheep), grazing livestock should be prohibited in proximity to Dall sheep range. To prevent conflicts, livestock susceptible to brucellosis should not be grazed on ranges used by caribou herds known to be infected with Brucella suis type 4. If Alaskans do not learn from experiences elsewhere or they fail to prevent importation of disease, reduction in numbers and/or vigor of some wildlife populations is a certainty.

Predation on Livestock by Wildlife:

As agriculture expanded across the United States, large predators were reduced or extirpated to prevent livestock losses. Also faced with shrinking habitat, the wolf (Canis lupus), cougar (Felis concolor), grizzly bear, and black bear are now found on minute portions of their previous ranges. The effect of large numbers of these predators on livestock is largely forgotten by stockmen today who are mainly concerned with the coyote (Canis latrans). In Alaska, we can expect losses of predators reminiscent of the 1800's if large livestock operations are begun. Large predators and livestock are incompatible; legal and/or illegal predator control will follow livestock losses.

Even today, with few predators remaining in the continental United States, predation on livestock may be severe where livestock are kept on ranges with populations of large predators. Animal husbandry practices, such as allowing cattle to pasture or calve in wooded or brushy areas, can facilitate predation. Livestock which die from other causes are difficult to find and livestock owners may assume missing animals have been lost to predators (Fritts 1982). Livestock carrion from either improper disposal or pasture deaths attract predators and accustom them to the odor and taste of livestock. Consumption of carrion by predators usually results in the assumption that predation was the cause of death (Bjorge 1980, Fritts and Mech 1981).

Coyotes are the only large predator left in abundance in the continental United States because control programs have not been as effective on coyotes as on other large predators. Predation of coyotes on domestic sheep and other livestock in the western

United States has received considerable attention. Studies in North America show coyotes are responsible for a loss of 1-6% of range sheep and usually kill lambs (Early and Roetheli 1974, Dorrance and Roy 1976, Klebenow and McAdoo 1976, Taylor et al. 1977, Tigner and Larson 1977). Losses vary with different ecosystems, flock sizes, management practices, and seasons (Dorrance and Roy 1976, Nass 1977). Coyotes also kill a small percentage of calves and poultry (Andelt and Gipson 1979, Gee 1979). The magnitude of predation is a function of livestock availability, not predator density, and some coyotes are more likely to kill livestock than others (Connolly et al. 1976, Boggess et al. 1978).

Coyote control is controversial, particularly the use of poisons. Lethal methods such as trapping and poisons are used although the use of poisons on Federal land and by Federal agents was banned in the 1970's to prevent losses of nontarget species. Other control methods aimed at prevention of predation and elimination of individual coyotes responsible for predation are also used. One selective killing method that can reduce losses in areas of high predation is use of toxic collars on sheep and goats (Wade and Connolly 1980). The effectiveness of repellents, notably lithium chloride, an emetic, has been debated (Gustavson et al. 1974); recent research indicates coyotes may associate the ill effects only with sheep carcasses and not live prey (Conover et al. 1977). Deterrent or directing fences can be used for small operations or where there are high losses, and electric fencing shows promise (DeLorenzo 1977, deCalesta 1980). Management practices such as shed lambing, night penning, daily checking, and hiring of experienced herders also reduce predation losses (McCabe and Kozicky 1972, deCalesta 1978, Wade and Connolly 1980).

Coyotes are present in Alaska and they have been observed hunting Dall sheep (D. Preston, pers. observ.). They would kill domestic livestock, particularly sheep, if given the opportunity. History indicates that coyote control, legal or illegal, will follow any predation on livestock by coyotes.

Wolf predation on livestock has occurred since historical times with the extirpation of wolves in most of the continental United States to prevent livestock losses. Studies in Minnesota and Alberta, where small numbers of wolves still remain, found wolf predation today is not a serious problem for the livestock industry as a whole but a small percentage of farms do suffer significant annual losses (Bjorge 1980, Fritts 1982). Both sheep and cattle are affected, and wolves select calves and yearlings over cows and bulls (Bjorge 1980). Although most wolves do not kill livestock even when available, evidence indicates single wolves and pairs may be responsible for more predation than packs (Bjorge 1980, Fritts 1982). In one area, depredations increased after a pack was reduced to 2 wolves (Bjorge and Gunson 1981 in Weaver 1981).

Historically, bounty programs were used to reduce wolf numbers and prevent livestock losses. Recent control programs have concentrated on trapping and killing individual wolves responsible for predation. Attempts to live-trap and relocate wolves have been unsuccessful because most wolves return to areas containing livestock (Fritts 1982). Effectiveness of control methods such as aversion baiting and use of flagging or lights has not been determined (Fritts 1982).

Alaska has large numbers of wolves. Wolves have been a problem for the reindeer industry, and wolf numbers have been reduced in reindeer grazing areas. Wolves now occasionally kill horses and cows, and livestock predation by wolves will increase as livestock numbers increase.

Large numbers of golden eagles (Aquila chrysaetos) and juvenile bald eagles (Haliaeetus leucocephalus) have been killed in the western United States in response to actual or perceived predation by eagles on sheep (O'Gara 1978). Since 1970, it has been illegal to kill any eagle without special permits, which are essentially impossible to obtain.

Low levels of predation by golden eagles were found in Texas (Wiley and Bolen 1971, Tigner and Larson 1977), but in Montana, golden eagles were responsible for 76% of all lamb deaths on 2 ranches where eagles killed lambs up to 50 lbs (O'Gara 1978). Predation on domestic animals is greater when populations of natural prey are low (Mollhagen et al. 1972, O'Gara 1978). Effects of livetrapping and removing eagles on lamb predation was inconclusive; the expense and difficulty made it impractical. Scare tactics have not been evaluated. History indicates if legal control is not possible, illegal hunting will occur anyway, resulting in losses of juvenile bald eagles as well as golden eagles (O'Gara 1978).

Killing of bears by ranchers to prevent predation on livestock has contributed to the extirpation of grizzly bears over much of their range and the reduction of black bears, and the conflict between bears and livestock continues today. For example, in areas adjacent to Yellowstone National Park, bears killed sheep opportunistically and some bears killed cattle (Knight and Judd 1980). Bears ate cattle carrion resulting in perception by livestock owners of increased predation. In this area, black bears and grizzly bears were responsible for 34% and 15%, respectively, of sheep lost on heavily forested sheep allotments during 1976-77 (Johnson and Griffel 1982). Livestock-killing bears were of both sexes and a range of ages. All sheep predation occurred on sheep bedgrounds in mid- and late summer. Grizzly bears rather than black bears were responsible for cattle deaths in Wyoming, and predations continued even after a number of bears were removed (Murie 1948).

Alaska has large numbers of grizzly and black bears throughout the State. The ongoing conflict between brown bears and cattle on Kodiak Island has resulted in the legal and illegal removal of large numbers of bears and typifies the expected results in other areas of the State.

Johnson and Griffel (1982:789) cited 3 management concerns associated with grazing domestic sheep in grizzly bear habitat and the concerns apply with other livestock also.

1. "...bear-livestock conflicts will reoccur as new individuals learn to exploit livestock as a food source."

2. "Without continual removal of depredating grizzly bears, livestock losses can be expected to increase...."

3. "...grizzly bears [are vulnerable] to man-caused mortality when they become habituated to taking livestock."

It is easy for herders to kill bears because bears tend to return to a carcass. Knight and Judd (1980) concluded, "Sheep grazing should be reduced as much as possible on grizzly range and cattle grazing allowed only on an absorbed loss basis."

In Alaska we can also expect losses of livestock to lynx (Lynx canadensis), wolverines (Gulo gulo), and ravens (Corvus corax) if large-scale livestock operations are implemented. There may be local increases in predation on game animals as well, following removal of livestock that have attracted predators (Bright 1971 in Johnson and Gartner 1975).

Large-scale livestock grazing in Alaska will result in losses of livestock to predators. Stockmen are not tolerant of any losses to predators, and legal or illegal predator control will follow. The extent to which predators will be eliminated is dependent on the scale of livestock grazing and the effort made to use nonlethal means to minimize predation.

To minimize conflicts, grazing should not be allowed in areas with high grizzly populations. Calving and lambing should be restricted to easily monitored areas. Proper disposal of livestock carrion should be required on all leases. Economic feasibility studies of grazing proposals must consider losses of livestock to predators.

Access Changes for Wildlife Users

Growth of agriculture can affect wildlife users by sometimes providing access into adjacent wildlife habitat for hunting or viewing, although often access to the agricultural land itself is limited. As the human population increases, more landowners are denying access to their land.

Studies show that following damage to fences, crops, or livestock, landowners were more likely to post their land (Rounds 1975, Saskatchewan Department of Tourism and Renewable Resources 1978). Trends are toward increased posting with hunting rights leased to individuals or groups (J. Jackson, pers. commun., Ga. Coop. Ext. Serv.; R. Lund, pers. commun.).

Alaskans are already experiencing changes in access related to agriculture. New roads in the Delta Barley Project have made large areas accessible to waterfowl, big game hunters, and nonconsumptive users of wildlife. However, the section line easements in this project were vacated and some farmers, concerned about property damage by hunters and for political reasons, have refused access to the agricultural land to both hunters and wildlife managers. Other large-scale projects may also call for the suspension of easements. On grazing leases, even if legal access is available, grazing operators may fence large areas making access more difficult with dogsleds or vehicles. As additional acreage is put into agriculture, particularly in proximity to heavily populated areas, we can expect more landowner-hunter conflicts.

The Department of Fish and Game should firmly oppose the revocation of any section line easements in agricultural projects and encourage use of gates in fences to preserve practical access. Hunters should be informed that vandalism and trespass often result in loss of hunting privileges on private lands.

BIBLIOGRAPHY

Introduction

The bibliography consists of a subject index to references, and a reference list. The index lists references by subjects using only the author(s) and date. References were listed under a broad subject heading if they refer to all or at least 3 of the subheadings. Also, articles not seen were usually listed under broad subjects headings because of the difficulty of determining the exact contents. Full citations are listed by author and date in the reference list.

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Lord and Ambrose 1981b.

e. Poisons

Besser 1978; deCalesta 1981; De Grazio et al. 1972; Ewing et al. 1976; Goodhue and Baumgartner 1965; Guarino 1972; Gunson 1980; Howard et al. 1977; Rogers 1974; Schafer 1978; Schafer and Brunton 1971; Schafer and Marking 1975; Schafer et al. 1973; Somers et al. 1981; Timm 1980; Timm and Johnson 1980; World Health Organ. 1979; Yom-Tov 1980.

f. Scaring devices

deCalesta and Hayes 1979; MacLennan 1973; Owen and Thomas 1975; Stier and Bishop 1981; Sugden 1976.

g. Trapping

Gunson 1977, 1980; Gunson and Cole 1977b.

h. Other techniques

Bullard et al. 1978; Craven 1980; Grelen and Thomas 1957; Gunson 1977, 1980; Gunson and Pipella 1977; Owen 1977; Stone and Danner 1980; Sugden 1976.

3. Evaluation of and Compensation for Damage

Colo. Div. of Wildl., no date; Demaree and Fagan 1981; MacLennan 1973; Stier and Bishop 1981; Sugden 1976; Tully and Greene 1981.

C. Access to Wildlife on Croplands

McIntire 1970; Rounds 1975; Sask. Dep. of Tourism and Renewable Resour. 1978.

III. Livestock Production and Wildlife

A. Effects of livestock grazing on wildlife habitat

Bowers and Hosford 1979; Doell 1966; Doell and Smith 1968; Gaufin et al. 1950; Gerhart and Fisser 1976; Gjersing 1975; Halloran 1943; Julander et al. 1950; Kantrud and Kologiski 1982; Kessler and Bosch 1982; Klebenow 1982; Kufeld 1968; Lauer 1976; Mackie 1978; Nielson 1978; Paulsen et al. 1970; Salyer 1962; Schrad et al. 1976; Scotter 1971; Smith et al. 1972; Stoddart and Rasmussen 1945; Thomas and Maser 1979a,b; Townsend and Smith 1977; U.S. For. Serv. 1968; Workman and Low 1976; Yde 1977.

1. Habitat alteration

Adams 1975, 1976; Ames 1977; Anderson and Scherzinger 1975; Branson and Payne 1958; Brown 1967; Buckhouse and Skovlin 1979; Bue et al. 1952; Burgess et al. 1965; Coles 1965, 1966; Davis and Winkler 1968; Demarchi 1970; Duff 1978; Gallizioli 1976, 1977, 1979; Gunderson 1968; Gunnell and Smith 1972; Hammond 1966; Hilliard 1974; Holechek 1980; Holt and Froslie 1979; Johnson 1964; Jones 1965; Julander 1951; Julander and Robinette 1950; Kaiser and Berlinger 1979; Kantrud 1981; Kennedy 1977; Kirsch 1969; Larsson 1969; Laycock et al. 1972; Longhurst 1957; Lusby 1970; McKean and Bartmann 1971; McMahan and Inglis 1974; Makowecki 1980; Marcuson 1977; Mattise 1978; Molini 1978; Mosconi and Hutto 1982; Page et al. 1978; Reynolds 1980; Ruyle et al. 1980; Ryder 1980; Scifres 1977; Scotter 1980; Severson and Boldt 1978; Sharpe et al. 1976; Smith 1949; Thilenius and Hungerford 1967; Thilenius et al. 1975; Urness 1976; Van Velson 1978; Wallestad 1975; Whyte and Cain 1979; Whyte and Silvy 1981.

2. Wildlife use of rangelands

Bicak et al. 1982; Brothers 1976; Davis 1961; Egan and Agognino 1965; Flake et al. 1977; Hudson 1975a; Hunter et al. 1976; Julander 1951, 1952, 1955; Julander and Jeffery 1964; Kimball 1957; Mundinger 1976; Novakowski and Solman 1975; Phillips 1936.

B. Competition between livestock and wildlife

Booker 1958; Byerly 1978; Cook 1977; Darr and Klebenow 1975; Denney 1972; Firebaugh 1969; Fitch 1948; Gross 1970; Hall 1952, 1955; Julander et al. 1950; Kirsch et

al. 1978; Lauer 1976; Longhurst 1951; McMahan 1964, 1966; McMahan and Ramsey 1965; Mackie 1976, 1978; Newsome 1971; Pyrah 1973; Ramsey 1965; Rouse 1965; Smith A. D. 1958, 1961; Smith and Wilbert 1959; Stoddart and Rasmussen 1945; Swanson 1976; Ward et al. 1973; Windle 1961; Wing 1962; Yoakum 1975.

1. Cattle and wildlife

Ansotegui et al. 1972; Becker 1972; Blood 1966; Campbell 1972; Cole 1958; Coles 1965, 1966; Crane 1952; Dasmann 1949; Doell 1966; Dorn 1970; Drawe and Box 1968; Dusek 1975; Egan and Agognino 1965; Ellis and Travis 1975; Follows 1969; Gordon 1968; Gunnell and Smith 1972; Hansen and Gold 1977; Hansen and Reid 1975; Hansen et al. 1977; Hood and Inglis 1974; Howard et al. 1959; Hubbard and Hansen 1976; Jones 1960; Julander 1951, 1952, 1955, 1958; Julander and Jeffery 1964; Julander and Robinette 1950; Kirsch 1969; Knowles 1975; Koale 1981; Komberec 1976; Lesperance et al. 1970; Lisonbee 1972; McKean and Bartmann 1971; McLean and Willms 1977; Mackie 1970; Merrill et al. 1957; Morris 1956; Nagle and Harris 1966; Nelson and Burnell 1976; O'Meilia 1980; Olsen and Hansen 1977; Pearse 1968; Peden et al. 1974; Pederson and Henson 1970; Rice et al. 1974; Salter and Hudson 1980; Schwan 1945; Schwartz et al. 1977; Skovlin et al. 1968; Skovlin and Harris 1970; Smith and Doell 1968; Smith D. R. 1961; Sparks 1972; Stevens 1966; Stuth and Winward 1977; Van Vuren 1982; Willms et al. 1975, 1979, 1980.

2. Sheep and wildlife

Campbell 1972; Cole 1958; Dasmann 1949; Fennessy 1966; Follows 1969; Fulgham 1978; Fulgham et al. 1977; Hansen et al. 1977; Henne 1975; Jensen et al. 1972, 1976; Johnson 1962; Julander 1951, 1952, 1958; Longhurst et al. 1979; McKean and Bartmann 1971; Merrill et al. 1957; Morris 1956; Olsen and Hansen 1977; Pickford and Reid 1943; Rice et al. 1974; Schwan 1945; Schwartz et al. 1977; Smith 1965; Smith and Julander 1953; Smith et al. 1979; Sterner 1979; Stevens 1966; Stuth and Winward 1977.

3. Other livestock and wildlife

Klein and White 1978; Merrill et al. 1957.

C. Predation on livestock by wildlife

Byerly 1978; Denney 1972; Erickson and Wildl. Sci. Group 1976; Fritts 1982; Leopold 1964; Merrill 1965; Nesse 1974; Wade 1978.

1. Type of livestock

Boggess et al. 1978; Brown et al. 1976; Fairley 1969; Fritts and Mech 1981; Gipson 1975; Henderson et al. 1977; Hunter and Gunson 1980; Shelton and Klindt 1974; Shelton and Wade 1979; Sitton 1978; Swanson 1976; Weaver 1981; Weaver and Sitton 1978.

a. Cattle

Bjorge 1980; Bjorge and Gunson 1981; deCalesta 1978; Denney 1974; Eide 1965; Formozov and Golov 1975; Gee 1979; Gilbert 1949; Griffel 1982; Knight and Judd 1980; Meinzer et al. 1975; Murie 1948.

b. Poultry

Andelt and Gipson 1979.

c. Sheep

Arthur 1978; Beasom et al. 1977; Bolen 1975; Bowns 1976; Bowns et al. 1973; Connolly et al. 1976; Davenport et al. 1973; Davenport 1953; deCalesta 1978, 1980; DeLorenzo and Howard 1976; Denney 1974; Dorrance and Bourne 1980; Dorrance and Roy 1976; Early and Roetheli 1974; Early et al. 1974a,b; Ellins et al. 1977; Fagre and Teranishi 1982; Fennessy 1966; Gee et al. 1977a; Gilbert 1949; Gober 1979; Griffel 1982; Gustavson et al. 1974; Howard and Shaw 1978; Johnson and Gartner 1975; Johnson and Griffel 1982; Kauffeld 1977; Klebenow and McAdoo 1976; Knight and Judd 1980; Larsen and Dietrich 1970; Larson et al. 1975; Lynch and Nass 1981; McAdoo and Klebenow 1978; Magleby 1975; Mann 1968; Meduna 1977; Mollhagen et al. 1972; Moore et al. 1966; Nass 1977; Nesse 1973; Nesse et al. 1976; Nielson and Curle 1970; O'Gara 1976, 1978; Ogden and Lewis 1979; Pringle 1977; Reynolds and Gustad 1971; Rof Cordina 1965; Rowley 1969; Safford and Hoversland 1960; Savarie and Sterner 1979;

Shelton 1973; Shelton and Thompson 1976; Swanson and Scott 1973; Taylor and Workman 1979; Taylor et al. 1977; Tigner and Larson 1977; Voll 1967; Wagner and Pattison 1973; Wankier 1966; Whiteman 1978; Wiley and Bolen 1971.

d. Other livestock

Beasom et al. 1977; Hanson, H. C. 1952; Lynch and Nass 1981; Mollhagen et al. 1972; Rof Cordina 1965; Shelton and Thompson 1976; Wade and Connolly 1980; Wiley and Bolen 1971.

2. Predator management methods

Alberta Fish and Wildl. Div., no date; Balser 1974a; Clark 1975; Connolly and Longhurst 1975; Cringan 1976; deCalesta 1980; Dolnick et al. 1976; Dudderar 1977b; Gee et al. 1977b; Gottschalk 1967; Gum et al. 1978; Guthery 1977; Henderson and Boggess 1977; Merrill 1970; Sterner and Shumake 1978b; U.S. Dep. of Inter., Fish and Wildl. Serv. 1978; Wade 1973, 1974.

a. Antifertility agents

Balser 1964; Linhart et al. 1968.

b. Disposal of livestock carrion

Andelt and Gipson 1979; Danner and Smith 1980; Fritts 1982; Todd and Keith 1976.

c. Fences

deCalesta and Cropsey 1978; DeLorenzo 1977; Dorrance and Bourne 1980; Gates 1978, 1980; Gates et al. 1978; Thompson 1976, 1978, 1979; Whiteman 1978.

d. Hunting

deCalesta 1976a; Shelton and Klindt 1974; Wade 1976.

e. Poisons

Burns 1980; Conover et al. 1977; Ellins et al. 1977; Gustavson 1979; Gustavson et al. 1974, 1976; Guthery and Beasom 1978; Larsen and Dietrich 1970; Lynch and Nass 1981; Savarie and Sterner 1979; Sterner 1979; Sterner and Shumake 1978a; Wade and Connolly 1980.

f. Reducing livestock vulnerability

deCalesta 1978; Fritts 1982.

g. Scaring devices

Fritts 1982.

h. Trapping

deCalesta 1976a; Fritts 1982; Guthery and Beason 1978; Shelton and Klindt 1974.

i. Other methods

Bullard et al. 1978; deCalesta 1976a; Fagre and Teranishi 1982; Lehner et al. 1976; Shelton and Thompson 1976; Wade 1976.

3. History and philosophies of predator management

Arthur et al. 1977; Balser 1974b; Bates 1975; Berryman 1972; deCalesta 1976b; Howard 1974; Johnson and Gartner 1975; McCabe and Kozicky 1972; Presnall 1948; Pringle 1977; M. A. Smith et al. 1972; Wagner 1972, 1975.

4. Compensation for predator damage

Bowns 1976; DeLorenzo and Howard 1976; Hunter 1979; Tully and Greene 1981; U.S. Congr., House Comm. on Agric. 1972.

D. Access to wildlife on rangelands

McIntire 1970; Rounds 1975; Sask. Dep. of Tourism and Renewable Resourc. 1978.

E. Disease transmission between livestock and wildlife

Beckman 1967; Choquette 1961; Curtis 1980; Davis and Anderson 1971; Davis et al. 1970; DeArment 1972; Denney 1972; Friend 1976; Hayes 1978; Healey 1966; Irvin 1966, 1968; Quortrup et al. 1957; Roth 1968, 1972; Shillinger 1937; Smith et al. 1982b; Stauber 1976; Stauber et al. 1980; Valadao 1966; Wells et al. 1981.

1. Transmission of bacterial diseases

Binninger et al. 1980.

a. Anthrax

Choquette et al. 1972; Cousineau and McClenaghan 1965; Good 1956; Novakowski et al. 1963.

b. Brucellosis

Adrian and Keiss 1977; Choquette et al. 1978; Corner and Connell 1958; Creech 1929; Davidov 1974; Davis et al. 1979; Denney 1965; Diesch et al. 1972; Dieterich et al. 1979; Fenstermacher and Olsen 1942; Ferris et al. 1961; Grekova and Gorban 1978; Hayes 1977; Hoq 1978; Hudson 1978; Hudson et al. 1980; Huntley et al. 1963; Jellison et al. 1953; Meagher 1973a,b; Merrell and Wright 1978; Neiland 1970, 1975; Neiland and Miller 1981; Neiland et al. 1968; Rush 1932; Thorne and Morton 1976; Thorne et al. 1978a,b, 1979; Vashkevich 1973; Witter 1981.

c. Leptospirosis

Abdulla et al. 1962; Adrian and Keiss 1977; Andrews et al. 1964; Bolotzky et al. 1974; Cirone et al. 1978; Denney 1965; Diesch et al. 1972, 1970; Drewek et al. 1981; Ferris et al. 1961; Kahrs et al. 1964; Kir'yanov 1976; McGowan et al. 1963; Mincha 1970; Roth et al. 1961; Shotts and Hayes 1970; Sosov 1973; Stauber et al. 1977; Woods 1974.

d. Pasteurellosis

Foreyt and Jessup 1982; Heddleston and Gallagher 1969; Heddleston and Wessman 1973; Jessup 1981.

e. Q Fever

Enright et al. 1971a,b, 1969, 1971c; Hopla 1975; Rehacek et al. 1972; Riemann et al. 1978.

f. Tuberculosis

Choquette et al. 1961; Coffey 1977; Muirhead et al. 1974.

g. Other

Dennis 1967; Iskakov 1966; Kovalev et al. 1978; Merrell and Wright 1978; Page and Erickson 1969; Pohl and Thomas 1968; Thorpe et al. 1965.

2. Transmission of parasitic diseases

Becklund and Senger 1967; Karstad 1977; Kotrla and Kotrly 1977; Leader-Williams 1980; Longhurst and Douglas 1953; Samuel 1968; Trainer 1972.

a. Arthropoda

Addison et al. 1979; Cater 1968; Decker 1970; Follows 1969; Gray 1979; Hepworth and Thomas 1962; Kistner and Hayes 1970; Lange et al. 1980; Roberts and Meleney 1971; Sandoval 1979, 1980a,b; Wilkinson 1970; Williams 1980.

b. Cestoda

Prestwood et al. 1973.

c. Nematoda

Baker et al. 1957; Gates and Hibler 1970; Hibler and Adcock 1971; Kim 1974; Prestwood et al. 1973; Roneus and Christensson 1979; Schmitt et al. 1976.

d. Protozoa

Choquette et al. 1967; Christensen et al. 1962, 1959, 1960; Devaney 1967; Dubey 1981; Findlay and Begg 1977; Franti et al. 1976; Howe and Hepworth 1965; Howe et al. 1964; Hudkins-Vivion et al. 1976; Kapperud 1978; Maas et al. 1981; Magonigle and Eckblad 1979; Magonigle et al. 1975; Maruashvili and Bardzhadze 1966; Osebold et al. 1962; Peterson 1974; Peterson and Roby 1975; Peterson et al. 1973; Peteshev 1974; Renshaw et al. 1979, 1977; Riemann et al. 1978; Ryff and Bergstrom 1975; Stauber et al. 1977; Stepanova 1976; Vaughn et al. 1976; Wobeser 1976.

e. Trematoda

Bergstrom 1967; Foreyt and Hunter 1980; Foreyt and Todd 1976.

3. Transmission of viral diseases

Binninger et al. 1980; Boiko and Borisovich 1976; Hoff et al. 1974a; Kemp 1975; Lawman et al. 1978; Plowright 1968.

a. Contagious ecthyma

Blood 1971; Connell 1954; Dieterich et al. 1981; Hebert et al. 1977; Kummeneje and Krogsrud 1979; Lance et al. 1981; Nietsche and Lomholt 1980; Samuel et al. 1975; Smith et al. 1982a.

b. Bluetongue

Barber and Jochim 1975; Barrett and Chalmers 1975; Bowne 1973; Couvillion et al. 1980; Frank and Willis 1975; Hoff and Trainer 1974; Hoff et al. 1974b; Hourrigan and Klingsporn 1975; Howel 1963; Johnson et al. 1972; Jones and Foster 1978; Kistner et al. 1977; Luedke et al. 1967, 1969, 1970; Moore and Kemp 1974; Parks and England 1974; Prestwood et al. 1974; Robinson et al. 1967, 1974; Roughton 1975; St. George et al. 1980; Senft and Memolo 1980; Stair et al. 1968; Stauber et al. 1977; Thomas and Miller 1971; Thomas et al. 1974; Trainer and Jochim 1969; Vosdingh et al. 1968.

c. Bovine viral diarrhea

Barrett and Chalmers 1975; Couvillion et al. 1980; Dieterich 1981; Elazhary et al. 1981; Inverson et al. 1981; Johnson et al. 1972; Kahrs et al. 1964; McClurkin et al. 1979; Messick et al. 1974; Parks and England 1974; Stauber et al. 1977; Thorsen and Henderson 1971.

d. Epizootic hemorrhagic disease

Barber and Jochim 1975; Casals et al. 1966; Chalmers et al. 1964; Couvillion et al. 1980; Ditchfield et al. 1964; Feldner and Smith 1981; Fosberg et al. 1977; Foster et al. 1977; Hoff and Trainer 1973, 1974; Hoff et al. 1973; Jones et al. 1977; Karstad et al. 1961; Kistner et al. 1977; Parikh 1968; Prestwood et al. 1974; Roughton 1975; Stauber et al. 1977; Thomas 1971; Thomas and Miller 1971; Thomas et al. 1974; Wilhelm and Trainer 1966.

e. Foot and mouth disease

Kindiakov 1972.

f. Infectious bovine rhinotracheitis

Barrett and Chalmers 1975; Chow and Davis 1964; Dieterich 1981; Elazhary et al. 1981; Johnson et al. 1972; Kahrs et al. 1964; Parks and England 1974; Rampton and Jesset 1976; Rweyemamu 1970, 1974; Stauber et al. 1977; Thorsen and Henderson 1971; Thorsen et al. 1977.

g. Malignant catarrhal fever

Clark et al. 1970; Liggitt et al. 1980; Pierson et al. 1974; Ruth et al. 1977; Wyand et al. 1971.

h. Newcastle disease

Bradshaw and Trainer 1966; Hayes 1977.

i. Parainfluenza, type 3

Barrett and Chalmers 1975; Dieterich 1981; Elazhary et al. 1981; Howe et al. 1966; Jessup 1981; Johnson et al. 1972; Kahrs et al. 1964; Nyaga et al. 1981; Parks and England 1974; Parks et al. 1972; Stauber et al. 1977; Straver and Van Bekkum 1979; Thorsen and Henderson 1971; Thorsen et al. 1977.

j. Pseudorabies

Baskerville et al. 1973; Kirkpatrick et al. 1980; Trainer and Karstad 1963; Woods et al. 1980.

k. Rabies

Dozsa 1969; Vezey 1977.

l. Other

Barrett and Chalmers 1975; Elazhary et al. 1981; Kahrs et al. 1964; Parks and England 1974; Smart and Trainer 1975; Stauber et al. 1977; Trainer and Hoff 1971.

4. Control of disease transmission

Choquette et al. 1972; Coffey 1977; Gray 1979; Kistner and Hayes 1970; Meagher 1973a.

IV. Animal Classification

A. Class Amphibia and Class Reptilia - amphibians and reptiles

DeWitt et al. 1960; Hall 1980; Korschgen 1970; Marking and Chandler 1981.

B. Class Chondrichthyes and Class Osteichthyes - fish

Biro 1979; Bowers and Hosford 1979; Buckhouse and Skovlin 1979; Cope 1966; Cope et al. 1970; DeWitt et al. 1960; Duff 1978; Dykstra 1966a; Eaton 1973; Ferguson 1967; Flickinger et al. 1980; Folmar 1976; Friend and Trainer 1970; Gunderson 1968; Harrisson and Rees 1946; Ingham and Gallo 1975; Kenaga 1969; Kennedy 1977; Marcuson 1977; Mount and Stephan 1967; Mullison 1970b; Oberheu 1970; Rodgers and Stallings 1972; Schafer and Marking 1975; Sears and Meehan 1971; Smith and Isom 1967; U.S. Fish and Wildl. Serv. 1964; Van Velson 1978.

C. Class Aves - birds

Besser 1978; Bohmont 1967; Boiko and Borisovich 1976; Boudreau 1972; Brown 1974; Bull et al. 1976; Clark 1976; Cones and Jackson 1973; Connor 1960; deCalesta and Hayes 1979; De Grazio 1978; DeWitt et al. 1960; Enright et al. 1971c; Evans and Kerbs 1977; Ewing et al. 1976; Felton et al. 1981; Fimreite et al. 1970; Flickinger and King 1972; Flickinger et al. 1980; Friend and Trainer 1970; Fuchs 1967; Gallizioli 1976, 1979; Gilbertson and Reynolds 1974; Gjersing 1975; Goodhue and Baumgartner 1965; Grolleau and Giban 1966; Guarino 1972; Haseltine et al. 1981; Heath and Stickel 1965; Higgins 1975; Higgins and Kantrud 1973; Ingham and Gallo 1975; Ismail et al. 1974; Kantrud 1981; Kantrud and Kologiski 1982; Kapperud 1978; Kenaga 1969, 1973, 1979b; Kirsch et al. 1978; Larsson 1969; Leopold 1964; MacDonald 1979; Martinov 1970; Mendelssohn 1972; Mosconi and Hutto 1982; Mott et al. 1972; Moulding 1976; Oberheu 1970; Ogden 1980; Page et al. 1978; Parsons and Davis 1971; Price 1977; Rosene 1965; Ryder 1980; Schafer 1978; Schafer and Brunton 1971; Schafer and Marking 1975; Schafer et al. 1973; Schwab 1978; Smith 1965; Stewart 1973; Stone and Mott 1973; Stone et al. 1973; Tucker and Haegele 1971; U.S. Fish and Wildl. Serv. 1964; Warbach 1958; Ward 1979; Wegner and Merriam 1979; Whyte and Cain 1979.

1. Order Anseriformes - swans, geese, and ducks

Blus et al. 1979; Bossenmaier and Marshall 1958; Bradshaw and Trainer 1966; Bue et al. 1952; Burgess et al. 1965; Colls 1951; Duebbert and Kantrud 1974; Duebbert and Lokemoen 1976; Dustman et al. 1971; Dwernychuk and Boag 1973; Dwyer 1970; Flake et al. 1977; Flickinger 1979; Friend and Trainer 1974a,b; Fritzell 1975; Gates 1965; Gehring 1969; Gunnell and Smith 1972; Haegele and Tucker 1974; Hamilton and Stanley 1975; Hammond 1966; Hamor et al. 1973; Heath et al. 1972; Heinz 1976a,b; Hilliard 1974; Hirst and Easthope 1981; Hudson et al. 1972; Jennings et al. 1975; Jessen et al. 1964; Kaiser and Berlinger 1979; Kear 1963, 1970; Kenaga 1979a; Kirsch 1969; Krapu et al. 1973; Labisky 1957; MacLennan 1973; Martz 1967; Milonski 1958; Mundinger 1976; Neely and Davison 1966; Owen 1977; Owen and Thomas 1975; Patton and Frame 1981; Piccirillo and Quesenberry 1980; Quortrup et al. 1957; Rumble and Flake 1981; Ruyle et al. 1980; Salyer 1962; Serdiuk 1971, 1981; Stendell et al. 1977; Stewart and Kantrud 1973; Stier and Bishop 1981; Stone and Knoch 1982; Sugden 1976; Sugden and Goerzen 1979; Trainer 1972; Vermeer and Armstrong 1972; Whyte and Silvy 1981; Wright, In press; Zinkl et al. 1978.

2. Order Falconiformes - hawks, eagles, and falcons

Bolen 1975; Cade and White 1976; Dustman et al. 1971; Fimreite and Karstad 1971; Mendelssohn and Paz 1977; Mollhagen et al. 1972; O'Gara 1976, 1978; Parker 1976; Peakall 1976; Shrubb 1980; Tigner and Larson 1977; Wiemeyer et al. 1975; Wiley and Bolen 1971; Yom-Tov 1980.

3. Order Galliformes - grouse, quail, and pheasants

Beasom and Scifres 1977; Bridges and Andrews 1977; Burrage and Saha 1972; Buss and Dziedzic 1955; Carr 1968; Feldt 1966; Fredrickson et al. 1978; Galbreath 1973; Gallo et al. 1975; Grolleau 1965; Haegele and Tucker 1974; Heath et al. 1972; Horak 1974; Jennings et al. 1975; Joselyn and Tate 1972; Kenaga 1979a; Kessler and Bosch 1982; Kirsch et al. 1973; Klebenow 1982; Kopischke 1972; Kufeld 1968; Labisky 1975; Labisky and Lutz 1967; Lavaur and Arnold 1977; Lutz-Ostertag and Lutz 1970, 1973; Mattise 1978; Messick et al. 1974; Molini 1978; Mullins et al. 1977; Neill et al. 1971; Nielson 1978; O'Neil 1967; Olsen 1978; Page and Erickson 1969; Pheasant Task Force, no date; Quortrup et al. 1957; Schultz and Brooks 1958;

Somers et al. 1973, 1974; Stromborg 1977, 1979; Swanson and Yocom 1958; Talmon and Hanzlick 1978; Tejning 1967; Vance 1976; Wallestad 1975; Warner and Joselyn 1978; Watkins et al. 1978; Yde 1977; Ziegler 1978; Zorb 1957.

4. Order Gruiformes - cranes

Drewien 1974; MacLennan 1973; Serdiuk 1981.

5. Order Passeriformes

Mendelssohn and Paz 1977.

a. Family Corvidae - jays, crows, and magpies

Dennis 1967; Dolbeer 1980; Larsen and Dietrich 1970; Rowley 1969; Schafer 1972.

b. Family Icteridae - blackbirds

De Grazio et al. 1972; Rogers 1974; Somers et al. 1981; Stone and Danner 1980.

c. Other passerines

Bart 1979; Owens and Myres 1973; Schafer 1972.

6. Other orders

Bell and Dimmick 1975; Bicak et al. 1982; Braun et al. 1977; Hill and Mendenhall 1980; Johnson and Timm 1981; Kapperud 1978; Lavaur and Arnold 1977; Page and Erickson 1969; Pohl and Thomas 1968; Scott et al. 1975; Wilson 1978; Zinkl et al. 1981.

D. Class Mammalia - mammals

Bohmont 1967; Boiko and Borisovich 1976; Connor 1960; DeWitt et al. 1960; Enright et al. 1971a; Franti et al. 1976; Friend and Trainer 1970; Martinov 1970; Metcalf et al. 1968; Mincha 1970; Milhaud and Pinault 1977; Oberheu 1970; Ogden 1980; Onderscheka 1978; Oxley et al. 1974; Rehacek et al. 1972; Schafer et al. 1973; Shilova et al. 1968; Trainer and Karstad 1963; U.S. Fish and Wildl. Serv. 1964; Witter 1981.

1. Order Lagomorpha - hares and rabbits

Gehring 1969; Golley et al. 1975; Hansen and Gold 1977; Kaluzinski and Pielowski 1976; Lavaur and

Arnold 1977; Myllymaeki 1975a; Pelikan and Nesvadbova 1979; Phillips 1936; Pielowski and Zdzislaw 1974; Santini 1974; Schrad et al. 1976; Vance 1976.

2. Order Rodentia - rodents

Branson and Payne 1958; Christiansen 1979; Dudderar 1977a; Dykstra 1966b; Fimreite et al. 1970; Fitch 1948; Golley et al. 1975; Hansen and Gold 1977; Grodzinski et al. 1977; Hayes 1977; Howard et al. 1977; Hull 1971; Iskakov 1966; Johnson 1964; Keith et al. 1959; Kenaga 1979a; Kirkpatrick et al. 1980; Korschgen 1970; Leopold 1964; Longhurst 1957; MacDonald 1979, 1980; Marsh et al. 1977, 1970; Mendelssohn and Paz 1977; Myllymaeki 1975a,b; O'Meilia 1980; Page et al. 1978; Pelikan and Nesvadbova 1979; Prakash 1976; Reynolds 1980; Robel et al. 1972, 1981; Schmitt et al. 1976; Schrad et al. 1976; Timm 1980; Timm and Johnson 1980; Wegner and Merriam 1979; Wolfe and Esher 1980; Woods 1974.

3. Order Carnivora

a. Family Canidae

Dolnick et al. 1976; Neiland 1970, 1975; Neiland and Miller 1981; Riemann et al. 1978.

1) Coyotes

Andelt and Gipson 1979; Arthur 1978; Balser 1964, 1974a,b; Beasom et al. 1977; Boggess et al. 1978; Bowns et al. 1973; Burns 1980; Connolly and Longhurst 1975; Connolly et al. 1976; Conover et al. 1977; Danner and Smith 1980; Davenport et al. 1973; Davis et al. 1979; deCalesta 1976a,b, 1978, 1980; deCalesta and Cropsey 1978; DeLorenzo 1977; Dorrance and Bourne 1980; Dorrance and Roy 1976; Drewek et al. 1981; Dudderar 1977b; Early and Roetheli 1974; Early et al. 1974a,b; Ellins et al. 1977; Fagre and Teranishi 1982; Gates 1978, 1980; Gates et al. 1978; Gee 1979; Gee et al. 1977a,b; Gipson 1975; Griffel 1982; Gum et al. 1978; Gustavson 1979; Gustavson et al. 1974, 1976; Guthery and Beasom 1978; Henderson and Boggess 1977;

Henderson et al. 1977; Henne 1975; Howard and Shaw 1978; Johnson and Gartner 1975; Kauffeld 1977; Klebenow and McAdoo 1976; Larson et al. 1975; Lehner et al. 1976; Leopold 1964; Linhart et al. 1968; Lynch and Nass 1981; Magleby 1975; Meduna 1977; Meinzer et al. 1975; Nass 1977; Nesse 1974; Ogden and Lewis 1979; Pringle 1977; Reynolds and Gustad 1971; Roy and Dorrance 1978; Savarie and Sterner 1979; Shelton 1973; Shelton and Klindt 1974; Shelton and Thompson 1976; Shelton and Wade 1979; Sterner 1979; Sterner and Shumake 1978a,b; Taylor and Workman 1979; Thompson 1976, 1978, 1979; Todd and Keith 1976; Wade 1973, 1978; Wade and Connolly 1980; Wankier 1966.

2) Wolves

Bjorge 1980; Bjorge and Gunson 1981; Formozov and Golov 1975; Fritts 1982; Fritts and Mech 1981; Gustavson et al. 1976; Hanson 1952; Rof Cordina 1965; Tigner and Larson 1977; Weaver 1981.

3) Foxes

Bell and Dimmick 1975; Christiansen 1979; Dudderar 1977b; Fairley 1969; Frank and Van Hove Holdrinet 1979; Kirkpatrick et al. 1980; Knapp 1978; Mann 1968; Maruashvili and Bardzhadze 1966; Moore et al. 1966; Roneus and Christensson 1979; Schitoskey 1975.

4) Dogs

Boggess et al. 1978; Brown et al. 1976; deCalesta 1978; Denney 1974; Deichmann et al. 1971; Dorrance and Roy 1976; Gee 1979; Lehner et al. 1976.

b. Family Ursidae

Early and Roetheli 1974; Griffel 1982; Lord and Ambrose 1981b; Lowery 1954; Murie 1948; Nass 1977; Neiland and Miller 1981; Schmitt et al. 1976; Voll 1967.

1) Black bears

Binninger et al. 1980; Davenport 1953; Gilbert 1949; Gunson 1977, 1980; Gunson

and Cole 1977a,b; Gunson and Pipella 1977; Landers et al. 1979; Lord 1979; Lord and Ambrose 1981a; Pine 1954; Tigner and Larson 1977; Tully and Greene 1981; Wynnyk and Gunson 1977.

2) Brown bears

Eide 1965; Erickson and Wildl. Sci. Group 1976; Hunter and Gunson 1980; Johnson and Griffel 1982; Knight and Judd 1980; Neiland 1975; Singer and Maurer 1979.

c. Family Procyonidae - raccoons

Diesch et al. 1970; Frank and Van Hove Holdrinet 1979; Kirkpatrick et al. 1980.

d. Family Mustelidae - mustelids

Coffey 1977; Frank and Van Hove Holdrinet 1979; Muirhead et al. 1974; Tumanov 1974.

e. Family Felidae - cats

Riemann et al. 1978; Sitton 1978; Tully and Greene 1981; Weaver and Sitton 1978.

4. Order Artiodactyla

a. Family Suidae - Domestic swine

Baskerville et al. 1973; Kirkpatrick et al. 1980; Roneus and Christensson 1979.

b. Family Cervidae

Chalmers et al. 1964; Trainer and Jochim 1969; Tully and Greene 1981.

1) Elk

Adrian and Keiss 1977; Anderson and Scherzinger 1975; Blood 1966; Cole 1958; Corner and Connell 1958; Denney 1965; Foreyt and Hunter 1980; Gates and Hibler 1970; Gordon 1968; Greenwood et al. 1967; Hansen and Reid 1975; Hepworth and Thomas 1962; Howe and Hepworth 1965; Howe et al. 1964; Hunt 1979; Jones, D. A. 1960; Jones, W. B. 1965; Julander and Jeffery 1964; Knowles 1975; Koale 1981; Komberec 1976; Kufeld 1968; Mackie 1970;

Magonigle and Eckblad 1979; Merrell and Wright 1978; Merrill et al. 1957; Morris 1956; Mueggler 1966; Nagle and Harris 1966; Nelson and Burnell 1976; Olsen and Hansen 1977; Pickford and Reid 1943; Rush 1932; Salter and Hudson 1980; Schwan 1945; Skovlin and Harris 1970; Skovlin et al. 1968; Smith D. R. 1961; Stevens 1966; Thorne and Morton 1976; Thorne et al. 1978a, 1979, 1978b; Vaughn et al. 1976; Ward et al. 1973.

2) Moose

Addison et al. 1979; Ahlen 1975; Capel and Pandey 1972; Corner and Connell 1958; Diesch et al. 1972; Dorn 1970; Dubey 1981; Fenstermacher and Olsen 1942; Good 1956; Hudson 1978; Hudson et al. 1980; Jellison et al. 1953; Johnson et al. 1972; Knowlton 1960; Mytton and Keith 1981; Rolley and Keith 1980; Salter and Hudson 1980; Thorsen and Henderson 1971; Trainer and Hoff 1971.

3) Caribou and reindeer

Choquette et al. 1967; Davidov 1974; Dieterich et al. 1979; Elazhary et al. 1981; Hanson, H. C. 1952; Hopla 1975; Kazanovski 1978; Klein and White 1978; Kummeneje and Krogsrud 1979; Leader-Williams 1980; Lundholm 1970; Neiland 1975; Neiland et al. 1968; Nietsche and Lomholt 1980; Vashkevich 1973; Wobeser 1976.

4) Deer

Abdulla et al. 1962; Adrian and Keiss 1977; Ahlen 1975; Andrews et al. 1964; Ansotegui et al. 1972; Baker et al. 1957; Barber and Nagy 1971; Beasom and Scifres 1977; Booker 1958; Borrecco et al. 1972; Bowne 1973; Brown and Decker 1979; Brown et al. 1977, 1978; Capel and Pandey 1972; Chow and Davis 1964; Christensen et al. 1962, 1960, 1959; Clark et al. 1970; Cole 1958; Couvillion et al. 1980; Crane 1952; Craven 1980; Dasmann 1949; Davidson et al. 1980; Davis and Winkler 1968; Denney 1965;

Ditchfield et al. 1964; Drawe and Box 1968; Dusek 1975; Egan 1960; Firebaugh 1969; Flyger and Thoerig 1962; Foreyt and Hunter 1980; Foreyt and Todd 1976; Fosberg et al. 1977; Foster et al. 1977; Frank and Willis 1975; Fulgham 1978; Fulgham et al. 1977; Gallizioli 1976, 1979; Gates and Hibler 1970; Gray 1979; Greenwood et al. 1967; Grelen and Thomas 1957; Hall 1952; Halloran 1943; Hayes 1977; Hoff and Trainer 1973, 1974; Hoff et al. 1973, 1974b; Hood and Inglis 1974; Howe and Hepworth 1965; Howe et al. 1964; Hubbard and Hansen 1976; Hudkins-Vivion et al. 1976; Jones et al. 1977; Julander 1952, 1955, 1958; Julander and Jeffery 1964; Karstad et al. 1961; Kimball 1957; Kistner and Hayes 1970; Knowles 1975; Koale 1981; Komberec 1976; Krefting and Hansen 1969; Kufeld 1968; Larson 1969; Lawman et al. 1978; Lisonbee 1972; Longhurst and Douglas 1953; Longhurst et al. 1979; McGowan et al. 1963; McKean and Bartmann 1971; McLean and Willms 1977; McMahan 1964, 1966; McMahan and Inglis 1974; McMahan and Ramsey 1965; McNeiil 1962; Maas et al. 1981; Mackie 1970, 1976; Magonigle et al. 1975; Merrill et al. 1957; Moore and Folk 1979; Mueggler 1966; Mullen and Rongstad 1979; Oliver 1973; Osebold et al. 1962; Parikh 1968; Peterson et al. 1973; Prestwood et al 1973, 1974; Ramsey 1965; Renshaw et al. 1979, 1977; Roughton 1975; Salter and Hudson 1980; Samuel 1968; Schwan 1945; Schwartz and Nagy 1974; Shotts and Hayes 1970; Skovlin and Harris 1970; Skovlin et al. 1968; Smith 1949; Smith and Julander 1953; Smith et al. 1979; Stair et al. 1968; Stauber et al. 1977; Stuth and Winward 1977; Sullivan and Sullivan 1979; Thilenius and Hungerford 1967; Thomas 1971; Thomas and Miller 1971; Thomas et al. 1974; Thorsen et al. 1977; Trainer 1972; Urness 1976; Vosdingh et al. 1968; Wilhelm and Trainer 1966; Wilkins 1957; Willms et al. 1975, 1979, 1980; Wingard et al. 1981; Workman and Low 1976; Wyand et al. 1971.

5) Other cervids

c. Family Antilocapridae - pronghorn antelope

Adrian and Keiss 1977; Barrett and Chalmers 1975; Becker 1972; Campbell 1972; Denney 1965; Dubey 1981; Ellis and Travis 1975; Greenwood et al. 1967; Howe and Hepworth 1965; Howe et al. 1964; Oakley 1973; Olsen and Hansen 1977; Pyrah 1973; Schwartz et al. 1977; Sundstrom and Hepworth 1967; Thorsen et al. 1977; Trainer and Jochim 1969; Windle 1961; Yoakum 1975.

d. Family Bovidae

Rampton and Jesset 1976.

1) Bison

Bergstrom 1967; Choquette 1961; Choquette et al. 1978, 1961, 1972; Corner and Connell 1958; Cousineau and McClenaghan 1965; Creech 1929; Egan and Agognino 1965; Findlay and Begg 1977; Heddleston and Gallagher 1969; Heddleston and Wessman 1973; Hopla 1975; Howe et al. 1964; Liggitt et al. 1980; Meagher 1973a,b; Novakowski et al. 1963; Peden et al. 1974; Peterson and Roby 1975; Rice et al. 1974; Rush 1932; Ruth et al. 1977; Ryff and Bergstrom 1975; Schwartz et al. 1977; Severson and Boldt 1978; Sparks 1972; Straver and Van Bekkum 1979; Van Vuren 1982; Zarnke and Taylor 1982.

2) Mountain goats

Hebert et al. 1977; Samuel et al. 1975.

3) Bighorn sheep and Dall sheep

Becklund and Senger 1967; Blood 1971; Buechner 1960; Cater 1968; Connell 1954; Decker 1970; Demarchi 1970; Dieterich et al. 1981; Follows 1969; Foreyt and Jessup 1982; Gallizioli 1976, 1977, 1979; Hailey et al. 1972; Howe et al. 1966; Jessup 1981; Lance et al. 1981; Lange et al. 1980; Lauer 1976; Parks and England 1974; Parks et al. 1972; Robinson et al. 1967, 1974; Samuel et al. 1975; Sandoval 1979, 1980a,b; Smith et al. 1982a,b; Trainer and Jochim 1969; Turner 1977, 1979; Williams 1980.

4) Domestic bovids

Adams 1975; Anderson and Scherzinger 1975; Andrews et al. 1964; Ansotegui et al. 1972; Austin 1967; Baker et al. 1957; Balser 1974b; Bergstrom 1967; Bowne 1973; Branson and Payne 1958; Bullington et al. 1955; Christensen et al. 1962, 1959; Cole 1958; Coles 1965, 1966; Dinning et al. 1948; Dozsa 1969; Ellis and Travis 1975; Enright et al. 1971b, 1969; Ferris et al. 1961; Foreyt and Hunter 1980; Foreyt and Jessup 1982; Foreyt and Todd 1976; Foster et al. 1977; Fraser 1963; Gates and Hibler 1970; Good 1956; Healey 1966; Hoff et al. 1974a; Hoq 1978; Hudkins-Vivion et al. 1976; Hunt et al. 1970; Jessup 1981; Johnson and Gartner 1975; Karstad 1977; Kistner and Hayes 1970; Klebenow and McAdoo 1976; Laycock et al. 1972; Longhurst and Douglas 1953; Luedke et al. 1969, 1967, 1970; McClurkin et al. 1979; Maruashvili and Bardzhadze 1966; Milhaud and Pinault 1977; Nyaga et al. 1981; Osebold et al. 1962; Page and Erickson 1969; Peden et al. 1974; Peteshev 1974; Roberts and Meleney 1971; Rweyemamu 1970, 1974; St. George et al. 1980; Samuel 1968; Severson and Boldt 1978; Smith 1949; Stepanova 1976; Thilenius and Hungerford 1967; Thilenius et al. 1975; Thorne and Morton 1976; Van Vuren 1982.

5) Other bovids

Dieterich et al. 1981; Hepworth and Thomas 1962; Nietsche and Lomholt 1980; Nyaga et al. 1981; Rweyemamu 1970.

e. Other Families

Beasom and Scifres 1977; Olsen and Hansen 1977; Rampton and Jesset 1976; Salter and Hudson 1980.

5. Other orders

deCalesta 1981; Diesch et al. 1970; Hansen and Reid 1975; Howard et al. 1959; Hubbard and Hansen 1976; Rampton and Jesset 1976; Wegner and Merriam 1979.

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Bolen, E. G. 1975. Eagles and sheep: a viewpoint. J. Range Manage. 28(1):11-17. Verified, 17 ref., DJP.

Verified,	17 ref.,	DJP.
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reference has been verified	number of references cited	Diane J. Preston has reprint

Formozov, A. N., and B. A. Golov. 1975. [Wolf predation on cattle in the Uralsk and Guryevsk oblasts]. Buill Moskovsk O Va Ispyt Prir, Otal Biol. 80(1):108-116. Russ., engl.

[Wolf...]	Russ.,	engl.
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transliteration of title	language if summary not English	language of summary if different than article

Language abbreviations used were:

Engl., engl. = English
Fr., fr. = French
Ger., ger. = German
Ital., ital. = Italian
Nor., nor. = Norwegian
Por., por. = Portuguese
Russ., russ. = Russian
Swe., swe. = Swedish

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APPENDIX A, Table 1. Computer searches used to compile agriculture/wildlife bibliography.

Reference service or data base	Types of literature searched	Dates searched	Subjects or key words[a]
USFWS	Federal Aid documents	1948-Oct 1980	Grazing and wildlife
		1948-Dec 1980	Agriculture and wildlife
		1952-Mar 1981	Disease transmission between wildlife and livestock
BIOSIS	Biological Abstracts and Bio Research Index	1974-Jun 1980	Biology, agronomy, and ecology codes matched with wildlife names
CAB[b]	Abstracting journals from Great Britain	1971-1980	Ungulates or bears matched with disease transmission
		1971-Jan 1982	Wildlife names matched with disease and livestock terms
		1972-Dec 1980	Wildlife, livestock, or fish matched with urea or toxicity terms
Agricola	Bibliography of Agriculture and other agricultural materials	1970-Feb 1982	Wildlife terms and agriculture terms
		1970-Dec 1980	Wildlife and livestock terms and pesticide names
		1975-Oct 1980	Wildlife, livestock, or fish matched with urea

APPENDIX A, Table 1. Continued.

Reference service or data base	Types of literature searched	Dates searched	Subjects or key words[a]
SSIE[c]	Publications of governmental agencies, universities, and nonprofit groups	1978-Jan 1981	Moose matched with agriculture terms
DOANE	Popular and nontechnical literature	1977-1979	Wildlife terms matched with agriculture
CHEM	Chemistry literature	1977-Oct 1980	Wildlife, livestock, or fish matched with urea or toxicity

[a] Wildlife names and terms included variations of the words: moose (Alces alces), Dall sheep (Ovis dalli), caribou (Rangifer tarandus), black bear (Ursus americanus), grizzly bear, brown bear (Ursus arctos), bison (Bison bison), wolf, coyote, fox, lynx, marten, wolverine, mink, beaver, muskrat, snowshoe hare, otter, wildlife, wildfowl, wild mammals, wild ruminant, game waterfowl, crane, geese, ducks.

Disease terms included variations of the following words: disease, disease transmission, contagious ecthyma, infectious bovine rhinotracheitis, bovine viral diarrhea, parainfluenza III, tuberculosis, malignant catarrhal fever, bluetongue, epizootic hemorrhagic disease, anaplasmosis, canine distemper, pseudorabies, leptospirosis, tularemia, ovine progressive pneumonia, vibrio fetus, toxoplasmosis, brucellosis, trichinosis.

Agriculture and livestock terms included variations of the following words: predation, competition, grazing, agriculture, domestic, livestock, cattle, sheep, pigs, poultry, rangeland, range, herbicide, pesticide, crop, irrigation, farm, depredation.

Pesticide terms included the following: pesticide, herbicide, insecticide, fertilizer, urea, 2,4-D, toxic, poison, treflan, glyphosate, MCPA, tordon, sencor, premerge, buctril, brominal, bromoxynil, bromacil, dacthal, paraquat, sodium chlorate, diazol, malathion, carbaryl, vitavax, kelthane, sodium metaborate.

[b] Commonwealth Agricultural Bureaux.

[c] Smithsonian Science Information Exchange.

APPENDIX A, Table 2. Game damage programs in the United States in 1979.

State	Annual monetary limit	Wildlife species covered	Types of damage covered	Property must be open to hunting
Colo.	No limit	Ungulates, cougar, bear	Orchards, crops, fences, forage, domestic animals	Yes[1]
Mass.	No limit	Deer	Commercial crops	Yes
N.H.	No limit	Deer, bear, rabbit, grouse	Orchards, alfalfa, grain, corn, Christmas trees, domestic animals	Yes
Pa.	<$25,000 total statewide	Bear	Apiaries, livestock, poultry	Yes
Utah	$2,000/cropowner	Ungulates, pheasant	Cultivated crops	No
Vt.	No limit	Deer, bear	Crops, orchards, apiaries, domestic animals	Yes
Wash.	$1,000/landowner	Deer, elk	Crops, rangelands, fences	Yes
W. Va.	No limit	Deer	Real or personal property	No
Wis.[2]	No limit-bear & deer $10,000/landowner for waterfowl	Deer, bear, waterfowl	Crops, orchards, Christmas trees, apiaries, domestic animals	Yes
Wyo.	No limit	Ungulates, waterfowl, game birds	Crops, improvements, extraordinary damage to rangeland and fences	Yes

[1] Fees up to $25 per season may be charged for big game hunting.

[2] Program discontinued in 1980.

APPENDIX A, Table 3. Serologic evidence in Alaskan wildlife of some livestock pathogens.

	No. positive/No. tested						
	Moose	Caribou	Bison	Dall sheep	Canines	Bears	Small mammals
Brucella sp.	1/39 (7)[a] 0/140 (3)	7/67 (7)	0/21 (7)	0/17 (7) 3/73 (2)	11/28 (4) 2/11 (4)	6/74 (7) 21/37 (4)	ND[b]
Leptospira sp.	1/37 (7) 9/50 (3)	1/61 (7)	0/21 (7)	0/17 (7) 0/73 (2)	+[c] (5)	6/74 (7) 1/28 (7)	1/78 (6)
Bluetongue	0/39 (7)	0/67 (7)	0/21 (7)	0/17 (7) 0/73 (2)	NS[d]	NS	NS
Epizootic hemorrhagic disease	2/39 (7)	0/67 (7)	0/21 (7)	8/17 (7)	NS	NS	NS
Infectious bovine rhinotracheitis	0/39 (7) + (1)	6/67 (7)	0/21 (7)	0/17 (7) 0/73 (2)	NS	NS	NS
Bovine viral diarrhea	0/39 (7) + (1)	2/67 (5,7) + (5)	0/21 (7)	0/17 (7) 0/73 (2) + (1)	NS	NS	NS
Parainfluenza III	0/39 (7) + (1)	0/67 (5,7) + (5)	14/21 (7)	0/17 (7) 1/73 (2) + (1)			
Pseudorabies	ND	ND	ND	ND	ND	ND	ND
Ovine progressive pneumonia	ND	ND	ND	0/73 (2)	NS	NS	NS
Contagious ecthyma	0/39 (7)	5/53 (7)	0/21 (7)	7/17 (7) 17/73 (2)	ND	ND	NS

APPENDIX A, Table 3. Continued.

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[a] (reference)

(1) Dieterich, R. A. 1918. Respiratory viruses. Pages 28-30 in R. A. Dieterich, ed. Alaskan wildlife diseases. Univ. Alaska, Fairbanks. 524pp.

(2) Heimer, W. E.., R. L. Zarnke, and D. J. Preston. In Press. Disease surveys in Dall sheep in Alaska (preparing for domestic grazing). In J. Bailey, ed. Biennial symposium of northern wild sheep and goats. Colo. State Univ., Ft. Collins, Colo. 1982.

(3) Neiland, K. 1974. Disease and winter mortality of moose. Alaska Dep. Fish and Game, Fed. Aid in Wildl. Rest. Prog. Rep., Proj. W-17-4, W-17-5, W-17-6, Job 1.96R. Juneau. 23pp.

(4) _____. 1975. Further observations on rangiferine brucellosis in Alaskan carnivores. J. Wildl. Dis. 11:45-53.

(5) Schutz, L., unpubl. data.

(6) Woods, F. N. 1974. Leptospira interrogans in the Ballum serogroup from a vole Microtus oeconomus (Pallas) in Alaska. J. Wildl. Dis. 10(4):33, 36-42.

(7) Zarnke, R. L. 1983. Serologic surveys for microbial pathogens. Alaska Dep. Fish and Game, Fed. Aid in Wildl. Rest. Prog. Rep., Proj. W-21-2, W-22-1, Job 18.5R. Juneau. 18pp.

[b] No data.

[c] Number tested not reported.

[d] Not susceptible.